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President's Report
Tom McDermott, N5EG

The previous issue of the TPRS Quarterly Report was the last one that we distributed by mail. Due to rising postage and printing costs, we have decided to distribute the QR electronically. Concurrent with the change, we have moved from the page setup program previously used to Word. Already, it's been somewhat of a chore to try and do page layout, but we'll give it a try. Hopefully can be formatted to look good without driving the editor crazy, then we generate PDF format for the TPRS web site.

TPRS

Quarterly Report

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If you would like to be sent an email reminder when the current issue becomes available electronically, please send me an email (n5eg@tapr.org) and I'll add you to the list that announces when they are available. Let me know what email address you would like the reminder sent to.

In the previous issue, we discussed the progress of the digital part of the spread spectrum project. Unfortunately, due to very busy schedules, not much additional work has occurred. The various different phase rotation states, and the ability of the Viterbi decoder to find them, and properly synchronize have been demonstrated, so for all practical purposes, the digital board is done. Not so with the RF board, which has been slowed by lack of people to work on it. It will take some time to see if we can locate additional people who are both qualified and have the time to work on the board – we've been able to come up with volunteers that have only one or the other so far!

In the rest of this issue, we will discuss the MT63 mode, which is starting to become more popular on the HF bands due to the availability of Windows code, and it's excellent performance. Part 8 of wireless LAN resources for LINUX will appear in a future issue of the QR.

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MT63

The MT63 mode is based on code originally written by Pawel Jalocha, SP9VRC, who wrote the software for the Motorola DSP development kit. Later Nino Porcino, IZ8BLY, ported it to Windows. It also has appeared in the MixW software as another of the operating modes.

Mt63 is fundamentally different than other modulation methods in that it uses a large number of carriers at the same time, in a method known as Orthogonal Frequency Division Multiplexing (OFDM). This same technique is the type of modulation used by ADSL modems, and it's been proposed for digital video and audio formats, primarily in European countries.

The method is practical because modern personal computers are able to implement the Fast Fourier Transform (FFT) very quickly. In the MT63 OFDM modulation scheme, 64 carriers are used, spaced evenly apart over a bandwidth of between 500 to 2000 hertz (depending on the operator-selected mode). The modulation rate of any individual carrier is pretty slow, but the aggregate data throughput is high because a large number of carriers are used. Each carrier is differentially BPSK modulated – meaning that each carrier is always present, but the phase of each carrier is reversed (or not) to modulate it.

The table shows the various parameters for the 3 different modes, and 3 different interleave lengths (very short, short, and long)

Mode bandwidth Hz.	Carrier Spacing, Hz.	Symbols per second	Interleave time per character, seconds
500 Hz	7.8125	5	3.2 very short
500 Hz	7.8125	5	6.4 short
500 Hz	7.8125	5	12.8 long
1000 Hz	15.625	10	1.6 very short
1000 Hz	15.625	10	3.2 short
1000 Hz	15.625	10	6.4 long
2000 Hz	31.25	20	0.8 very short
2000 Hz	31.25	20	1.6 short
2000 Hz	31.25	20	3.2 long

The IZ8BLY software includes a "very short" interleave mode, but other software packages do not have this option.

The fundamental technique used to generate the transmit waveform, and to decode the receive waveform is to transform the signal state using the FFT (or Inverse FFT). Another approach is to utilize individual channel demodulators.

To transmit a block of data, the individual 64 elements of the various signal states are assigned values representing the phase of each individual carrier (as a complex number). The amplitude of each carrier is constant. Then the Inverse

FFT transforms the individual tone levels to a time-domain representation of that information. The time-domain representation is the exact shape of the waveform to be transmitted for the period of time corresponding to the frequencies of the signal set.

Conversely on receive, the received audio is digitized and the Fourier transformed to the representation of the original signal states. Or course the receiving problem is always more complex owing the difficulty of synchronizing on the received audio at the proper time, and getting everything lined up and blocked correctly so that exactly one symbol state is captured in the block that is to be transformed.

Additionally, some care has to be taken with how the symbols are filtered in the time domain, because the FFT process naturally integrates the received symbols (which is a matched filter for what are known as ‘rectangular’ transmit pulses.

Pawel’s code uses a different technique. It has 64 parallel demodulators and Walsh decoders, and it uses a maximal-likelihood decoder to select the decoded symbol that was most likely transmitted (has the highest confidence).

One of the reasons that all the transformation is useful is that the HF channel has a lot of different distortions, particularly one known as selective fading. This selective fading causes one or several of the tones to get notched out at the receiver while the rest might be received without any problems.

This type of distortion can be deadly to a single, rapidly modulated carrier transmission, which is what we normally use at VHF, UHF, and Microwave frequencies for higher speed transmission unless a special receive filter can an adaptive equalizer is used – which is quite complicated.

MT63 encodes each transmit symbol over 64 tones, and over 16, 32, or 64 symbol times (depending on the interleave factor). The coding of the 64 tones uses a *Walsh* function (which generates a large code space with many redundant symbols. Sixteen of the 64 tones (bits) can be corrupted either by fading or by narrow band interference, yet the original transmitted value can still be accurately recovered. The interleave factor assures that if all 64 tones are temporarily disrupted that no single character is corrupted (until, of course, the duration of the corruption starts to approach the interleave time, after which errors start to occur). The reason for this is that on HF ‘hits’ to the data tend to occur in clusters, with most of the errors occurring very close to one another in time. By interleaving the data for transmission, and then de-interleaving it upon reception, the clustered ‘hits’ to the data are spread out in time in the received sequence. Thus MT63 is naturally resistant to several of the significant problems of the HF channel.

The interleave factor in MT63 can be adjusted from very short to long. The advantage of long interleaving is that the spreading out of the errors is very good, the disadvantage is that the receive has to receive an entire interleaved block before it can perform the de-interleaving process – for long interleave times, the receiver has to wait longer to receive an entire block. This can be annoying on typical keyboard-to-keyboard chats on HF due to the slowed turn around time.

In any communications channel that is dominated by *Rayleigh* fading, the more redundancy that can be introduced to the data and modulation, the better the performance will be. MT63 seems to hit many of these redundancy objectives quite well. Previously on RTTY, redundancy was accomplished by using multiple receivers with antennas separated by several wavelengths – this worked well because the fading on the two antennas was not correlated – meaning that it was not very common for the signal to fade on both antennas at the same time (but it does happen). Further, RTTY selective fading can be reduce by using 850 Hz. Shift instead of 170 Hz shift – the greater spacing of the mark and space frequencies means that statistically they will less often fade together the further separated in frequency they are.

While MT63 does not take advantage of diversity physical reception, it takes advantage of the other two type of diversity: frequency and time, and 2 out of 3 isn't bad.

Studies of HF have shown the value of multiple diversity, and MT63 seems to do rather well. The activity on MT63 is located mostly at 14.080 and 21.130, 500 Hz. Mode, short interleave, and at 28.130, 1 kHz, long interleave. But the activity is pretty scarce, even on the weekends. I would recommend that you try the IZ8BLY software, at:
http://ninopo.freeweb.supereva.it/iz8bly

It can also be found via the G3VFP website:
http://www.g3vfp.com

or the ZL1BPU website at:
http://www.qsl.net/zl1bpu.

I, along with a few others have transferred some binary files (JPEG) recently using MT63 file transfer mode, which is present only in the IZ8BLY software. The transfer rate using the 1 kHz. wide mode on 10 meters produced a throughput of about 500 bytes/minute, or about 8.33 bytes/second (66 bits/second). Some were able to copy the file with no errors, but I was not. Analysis of the errors in the received JPEG file indicates that they were spaced out throughout the file, clear evidence that one or two overwhelming error bursts during the reception exceeded the interleave depth. When the error bursts were de-interleaved, the errors were spread throughout the file. It should be noted that no automatic retry mechanism is used on MT63 file transfers, so it is very suitable for multipoint operation (e.g., SSTV style operation, where all the people listening to the net can receive the image at the same time).

This behavior suggests a well-known solution to improving the accuracy of the file transfer method, using two Forward-Error-Correction (FEC) codes, an inner code and an outer code. This method has been used in satellite deep-space communications for many years, and is a standard method is published in the consultative Committee for Space Data Systems (CCDSS) document 101.0-B-5, available on the web.

Phil Karn, KA9Q, has proposed a similar technique for improving the performance of the AO-40 telemetry transmission and reception process, and has published C and C++ code snippets. You can find the CCDSS document, Phil's code, and the Ao-40 proposal at his web site:
http://people.qualcomm.com/karn

In the technique, an inner code is applied to the data, a convolutional code. This type of code deals well with dribbles of data errors (non clustered errors). An outer code, a Reed-Solomon block code deals well with bursts of errors (recovering data even when multiple clusters of errors are present. Thus the strategy is to interleave the data between the inner and outer codes.

At the receiver, the outer code corrects as many burst errors as it can, then de-interleaves the data. Any burst errors longer than the accommodation length of the RS outer code result in error bursts that then get de-interleaved. This results in bit errors that are spread out throughout the file (just like the type of errors we saw with the MT63 files). The inner code (convolutional code) is decoded, and it cleans up the spread-out bit errors, resulting in a clean file.

Two ways to do this are possible: MT63 itself could be modified to incorporate a convolutional inner code, or else an external utility program could be written that transforms a file into a larger convolutionally coded file, and that does the inverse on receive. Either Fano or Viterbi decoders could be used in an off-line program.

Convolutionally coding data usually doubles the number of bits in the file; so using a punctured code (7/8 rate) would minimize the file size expansion with only a little loss in performance (this is covered in the CCDSS document).

Thanks to Mark, N5RFX for analyzing the received JPEG file errors.

Digital Mode UHF and VHF Band Plans

The Texas VHF-FM Society, Inc. adopted in February 1987, and revised in February 1988, band plans for the 2 meter and part of the 70 centimeter band in Texas. The general membership of the VHF-FM Society adopted these plans in August 1991, and revised in 1999. These plans determine where digital and packet modes are authorized to operate in Texas. The portions most applicable to packet and digital operation are underlined.

Normal (customary) digital usage, and clarification of the VHF-FM Society tables have been added by the QR. Please report any errors to the TPRS QR editor. These plans are printed with the permission of the Texas VHF-FM Society, Inc.

144 - 148 Mhz Band Plan

144.000 - 144.100	CW (The FCC assignment for 2 meters specifies this)
144.100 - 144.275	Weak Signal SSB (144.200 is the SSB calling frequency)
144.275 - 144.300	Propagation Beacons
144.300 - 144.500	Satelite Sub-band
144.390	APRS - Automatic Position Reporting System (Note: 1200 baud AFSK is normally used)
144.510 - 144.890	Repeater Inputs - paired with 145.110 - 145.490 Outputs
144.900 - 145.100	Packet (Note: 1200 baud AFSK is normally used)
145.110 - 145.490	Repeater Outputs - 20 Khz spacing on the odd 10 Khz channels
145.500 - 145.800	Simplex and Experimental
145.800 - 146.000	Satelite Sub-band
146.020 - 146.400	Repeater Inputs - paired with 146.620 - 147.000 outputs
146.400 - 146.600	Simplex (146.520 is the FM national calling frequency)
146.620 - 147.000	Repeater Outputs - 20 Khz spacing on the even 10 Khz channels Paired with 146.020 - 146.400 inputs
147.000 - 147.380	Repeater Outputs - 20 Khz spacing on the even 10 Khz channels
147.400 - 147.600	Simplex
147.600 - 147.980	Repeater Inputs - paired with 147.000 - 147.380 outputs

440 - 450 Mhz Band Plan

440.000 - 440.500	Digital Wideband Output (50 or 100 Khz wide)
440.525 - 440.725	Digital narrowband repeater Output (Note: 1200 baud AFSK is normally used)
440.750 - 440.975	Cross band repeat - fixed
441.000	Narrowband packet (Note: 1200 baud AFSK is normally used)
441.025 - 441.075	Simplex NBFM Voice
441.100 - 441.175	Simplex Narrowband digital (Note: 1200 baud AFSK is normally used)
441.200 - 441.275	Control channels (12.5 Khz spacing)
441.300 - 441.375	“Backyard” Repeater Output
441.400 - 441.475	Control channels (12.5 Khz spacing)
441.500 - 441.975	Low power NBFM Repeater Output
442.000 - 444.975	NBFM Repeater Output (25 Khz spacing)
445.000	NASA Select NBFM Audio
445.000 - 445.500	Digital Wideband Input (50 or 100 Khz wide. Note: scrambled 9600 baud direct FSK is normally used)
445.525 - 445.725	Digital Narrowband repeater Input (paired with 440.525 - 440.725, 25 Khz. spacing).
445.750 - 445.975	Crossband repeat - mobile
446.000	National Simplex NBFM calling frequency
446.025 - 446.075	Simplex NBFM voice
446.100 - 446.175	Simplex narrowband digital (25 Khz spacing. Note: 1200 baud AFSK is normally used)
446.200 - 446.275	One-way links (split site repeaters)
446.300 - 446.375	“Backyard” repeater input (25 Khz spacing, paired with 441.300 - 441.375)
446.400 - 446.475	One-way links (split site repeaters)
446.500 - 446.975	Low power NBFM Repeater Input (25 Khz spacing, paired with 441.500 - 441.975
447.000 - 449.975	NBFM repeater input (25 Khz spacing, paired with 442.000 - 444.975)

Texas Packet Radio Society, Inc.

TPRS was founded in 1985 and is an educational, public service, and scientific research non-profit corporation. Texas Packet Radio Society goals are:

1- design and research amateur radio packet networks
2- provide education in the area of general packet usage

To accomplish better communications in the region, TPRS has been organizing statewide working groups to cover various networking topics. The current working groups are the Mailbox/BBS Group, TCP/IP Group, and the TexNet Support Group. TPRS hopes that these working groups will help promote information exchange in their respected areas in Texas. New working groups are formed as needed to provide channels for discussion and to help provide direction for that area of digital communications. Anyone can participate in a working group; TPRS membership is not required.

TexNet

TPRS has established a digital packet network protocol, a standard hardware package for the network nodes, and software modules that implement the TexNet network.

The basic design philosophy of TexNet is an open, inexpensive, multi-resource, high speed 'backbone' with access through multi-connect capable local nodes. On the high speed side, TexNet is a 9600 baud network system. For local access, compatibility with the typical 2 meter AX.25, 1200 baud, AFSK/FM station is the operational norm. Other baud rates and modulation techniques can be supported on the primary user port or secondary port. The system is totally compatible with both versions of the AX.25 protocol specifications for user connections. With these general specifications, TexNet has been designed and tested to enable all users to take advantage of this high speed, full protocol protected packet network system.

Each node offers, in addition to TexNet access, local area digipeater service, 2 conference bridges for full protocol protected roundtable or net operation, a full mult-connect, multi-user mailbox system, a local console for installation and maintenance setups, a debugger module for long distance and local software monitoring,and an interface for a weather information server for regional weather information, if available.

The NCP-PC (TexNet for PC) creates a direct interface to the PC platform. The Z80 based PC card supports 4 channels for communications. This co-processor approach allows the AX.25 and TexNet-IP to run on the card without affecting the PC. This allows the full power of the PC to be used for network applications. The versatility of this board is only now being developed and applications are endless.

The TexNet Network

The Texas TexNet network system has been operational since October 1986. When fully operational, the network reaches from the border of Mexico to Missouri. Use of the Texas TexNet system is open to all amateur operators. TPRS has been coordinating the installation of the Texas TexNet system. Further expansion of the system depends entirely upon the amateur community.

INFORMATION

TPRS is interested in spreading our information and research efforts as widely as possible. We want other groups involved with packet efforts to get in contact with us. We will provide information for those amateur packet groups that are interested in this system for their areas. If you would like more information concerning TPRS or TexNet, please drop a letter to:

Texas Packet Radio Society, Inc.
P. O. Box 49142
Austin, Texas 78765-9142

TPRS MEMBERSHIP

TPRS membership is widespread with most members located in Texas, but members are located in other states and in foreign countries. Membership is open to any interested person. If you are interested in becoming a member and receiving the TPRS Quaterly, please send your name, address and call with membership dues of $12 per year.

TPRS Membership Application

Name ____ Callsign _______________

Address ____

Apt. or Mailstop ____________________

City/State ____

Zip ______________________ E-mail address _____________________________________

Evening Phone (   ) ____________________ Work Phone (   ) ________________________

Membership is $12 per year. How many years are you paying for? __________________

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